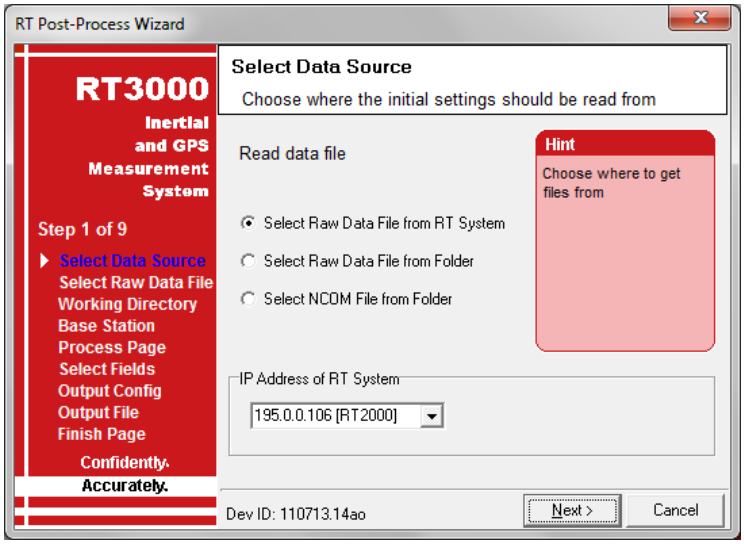
RT

Inertial and GPS Measurement Systems



RT Post-process User Manual

Confidently. Accurately.

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Introduction

RT Post-process is a wizard based application for reprocessing data from the RT and Inertial+ products from OxTS. With RT Post-process you can:

- Copy raw data (RD files) from an RT or an Inertial+ onto your computer.
- Apply different configurations and optimise the processing to get the best performance.
- Process the inertial data forwards and backwards in time in order to minimise the drift when GPS is not available.
- Use differentially corrected GPS data (requires other software). Raw GPS data can be exported from RT Post-process, combined with base-station data, then read back into RT Post-process and combined with the inertial data.
- Convert the binary output files into text formats.
- Crop or divide the output files into smaller sections and change the data rate of the files.

RT Post-process is a wizard based application that guides you through the steps of post-processing the data. Part of the process uses RT-Config or i+config to examine or change the configuration. It should be relatively easy to use RT Post-process and this manual serves mainly to explain some of the detail behind the options.

This manual refers to the RT throughout. However, RT Post-process has been designed to work with the Inertial+ as well as the RT products. All the features of RT Post-process will work correctly with the Inertial+ except where the manual explicitly states otherwise.

File storage within the RT

The RT usually logs a file to its internal storage whenever it is running. This file contains the configuration, the raw data from the inertial sensors and the GPS measurements. It does not normally include processed NCOM data; RT Post-process is needed to convert an RD file to an NCOM file.

When the RT boots it will start logging a file called “mobile.rd”. When GPS time is available the file will get renamed to yymmdd_hhmmss.rd, where “yy” is the year, the first “mm” is the month, “dd” is the day in the month, “hh” is the hour, the second “mm” is the minutes and “ss” is the seconds. GPS time is very close to UTC (or GMT). The filename does not have any local time offset applied to it.

When the disk space becomes full then the RT will erase the oldest RD file. RD files can be deleted by the user using FTP software. If the current RD file being written is deleted then the RT will continue to write to this file but it will no longer have all the post-processing functionality that other RD files have; the configuration files will be missing from the start.

The files are all put in the user partition of the storage in the RT and this partition can be accessed through FTP. RT Post-process includes an FTP server that can be used to view the files. Other FTP software, for example Explorer can be used to view the files as well. For FTP access an anonymous login can be used. Alternatively, use the login name “user” and the password “user”.

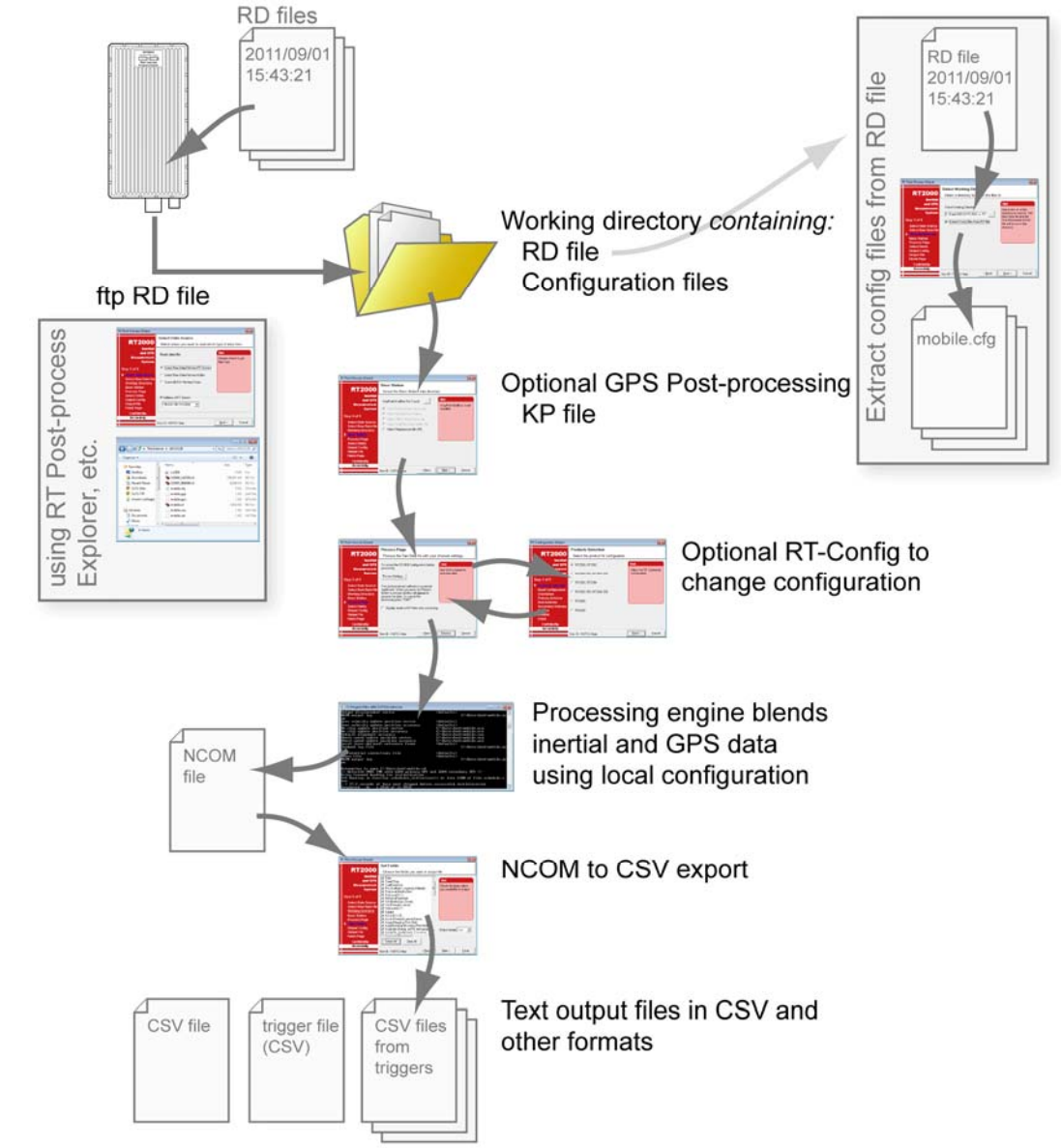
The configuration files (all starting with “mobile”) are also stored in this folder. These should not be deleted. They are modified by RT-Config (or i+config) and it is best to always use this software to update the configuration.

Post-processing workflow

Figure 1 shows the workflow for processing an RD file. The workflow uses a combination of RT Post-process and RT-Config (or i+config for an Inertial+).

The workflow is relatively simple and is as close to a “one-click” approach as we could make it.

Figure 1. Processing workflow overview for RT Post-process



At the start of the workflow an RD file will be transferred from the RT via FTP either using RT Post-process or using other FTP software. The file should be placed in a "working directory" where lots of files will be created. It is best to use one directory for each RD file to avoid confusion.

The configuration that is currently on the RT will be transferred using RT Post-process to the working directory. This configuration can be different to the configuration that was used in real-time and this can lead to incorrect results. RT Post-process can extract the configuration that was used when the RD file was written to the RT.

It is possible to post-process the GPS data using external software. This is easiest using GrafNav but other software can be used, for example GAMIT-GLOBK/TRACK. Contact OxTS if you want to use other software.

Before processing the data, RT-Config (or i+config) can be run. The configuration can be checked and changed before processing the data. This can be useful for fixing configuration problems, for applying a better configuration (e.g. a better known antenna position), for displacing the output to another location, etc.

The data is processed using a Win32 console application called blended.exe. This is developed at OxTS separately from the user application. It is possible to run this program as part of a batch file so that lots of RD files can be processed together.

Once blended has finished an NCOM file will have been created. This can be loaded into RT-View or exported to text format from RT Post-process. CSV, POS and OTA formats can be written. The text files can be the whole of the NCOM file or parts of it. The event input to the RT can be used to define the start and stop of the text files and it can be used to write a text file at the times of the events.

Minimum System Requirements

The minimum system specifications required to support the software are listed below.

- 512MB SDRAM
- 32-bit or 64-bit operating system
- Windows XP, Windows Vista, Windows 7

Installation

The software will be delivered either on a CD or as a zip file. The zip file does not need to be uncompressed before running the setup file. Double-click “RT-Setup.exe” to start the software setup. This will install the RT Software Suite which contains the following programs:

- Enginuity
- RT-Config
- RT Post-Process
- RT-View

If the unit is an Inertial+, double-clicking “I+Setup.exe” will install the Inertial+ Software Suite which contains the following programs:

- Enginuity
- I+Config
- RT Post-Process
- RT-View

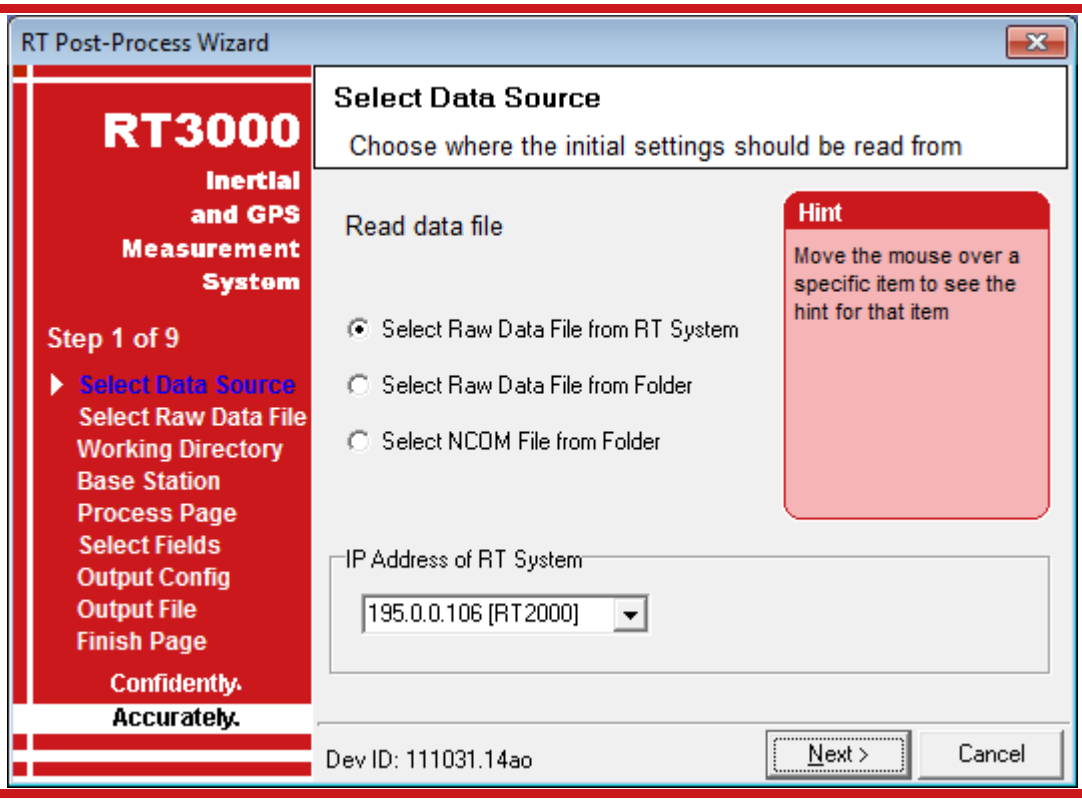
Both software suites can be installed at the same time.

Operation

An overview of the workflow for RT Post-process was given in the introduction. This section builds on the workflow and describes each step in more detail.

To run RT Post-process, go to the Windows Start menu, select All Programs, OxTS and click on RT Post-process. This will run the software. Figure 2 shows the window that will be displayed.

Figure 2. Select Data Source page



Select Data Source page

Three data sources can be selected. RD files can be selected from a folder or can be copied off an RT using FTP. If an NCOM file is available then this can be converted to text format (CSV, etc.). It is not possible to reprocess an NCOM file and change the settings that were used. Each option is described below.

Select Raw Data File from RT System. This option should be used to copy an RD file from the RT (using FTP). After selecting this option enter the IP address of the RT

that you want to read the files from. If the software can receive UDP data from the network then it will list all of the RTs that are currently broadcasting NCOM. Click Next to see the files on the RT.

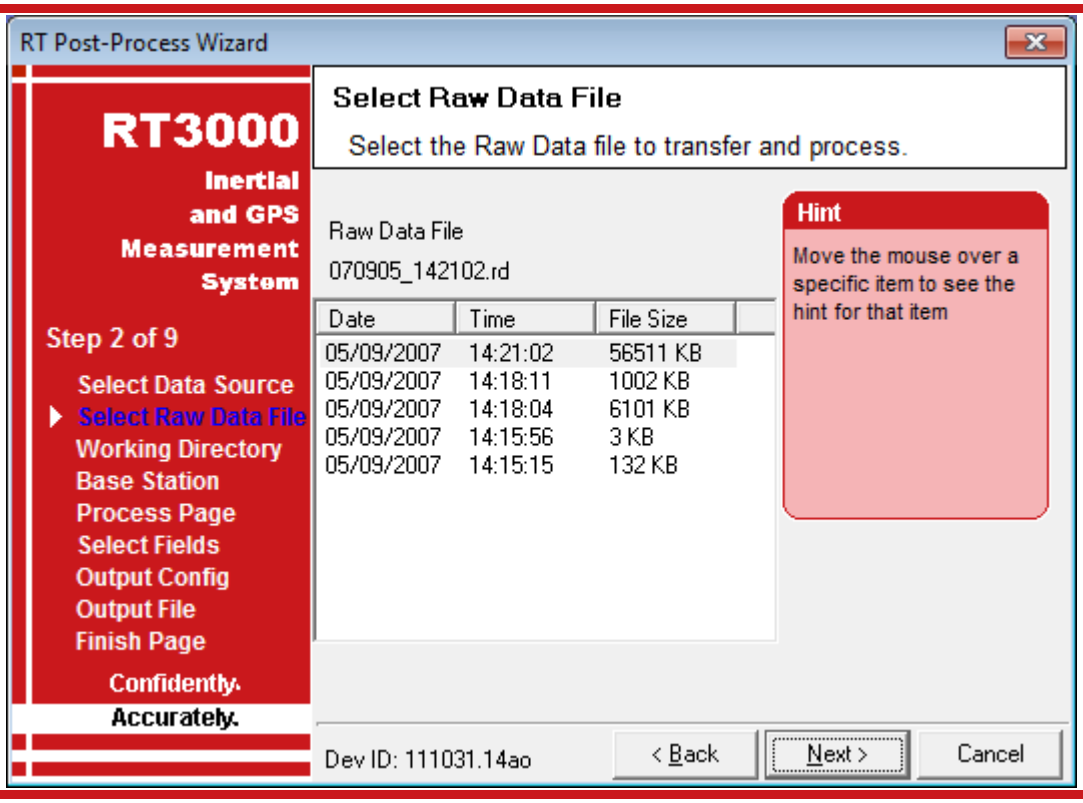
Select Raw Data File from Folder. This option should be used if the RD file is already on the PC. After selecting this option the "Raw Data File" group box will replace the "IP Address of RT System" group box. Select the RD file from a folder and click Next. The software will jump straight to the Working Directory page.

Select NCOM File from Folder. This option can be used to bypass the reprocessing stage and export the NCOM file to text format. After selecting this option the "NCOM File" group box will replace the "IP Address of RT System" group box. Select the NCOM file from a folder and click Next. The software will jump straight to the Select Fields page.

Select Raw Data File page

The Select Raw Data File page is only shown if the "Select Raw Data File from RT System" option is chosen from the "Select Data Source" page. Figure 3 shows the page with 5 files listed.

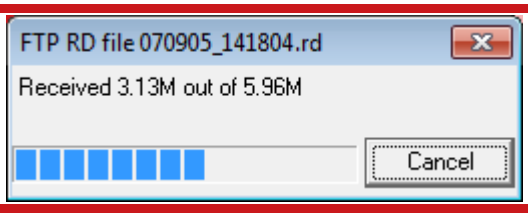
Figure 3. Select Raw Data File page



The date, time and file size of each file on the RT are listed. These are the start time of the file, in GPS time (very similar to UTC) when the GPS receiver in the RT found time. As an approximation, the RT will log about 20MB per hour, though this can change a lot depending on the RT. Single antenna systems log less data and dual-antenna Inertial+ systems can log more.

To upload a file from the RT select the file and click Next. The software will use FTP to get the file from the RT and save it in a temporary directory. The "FTP RD file…" window, in Figure 4, will show the progress.

Figure 4. FTP RD file… window



Working Directory page

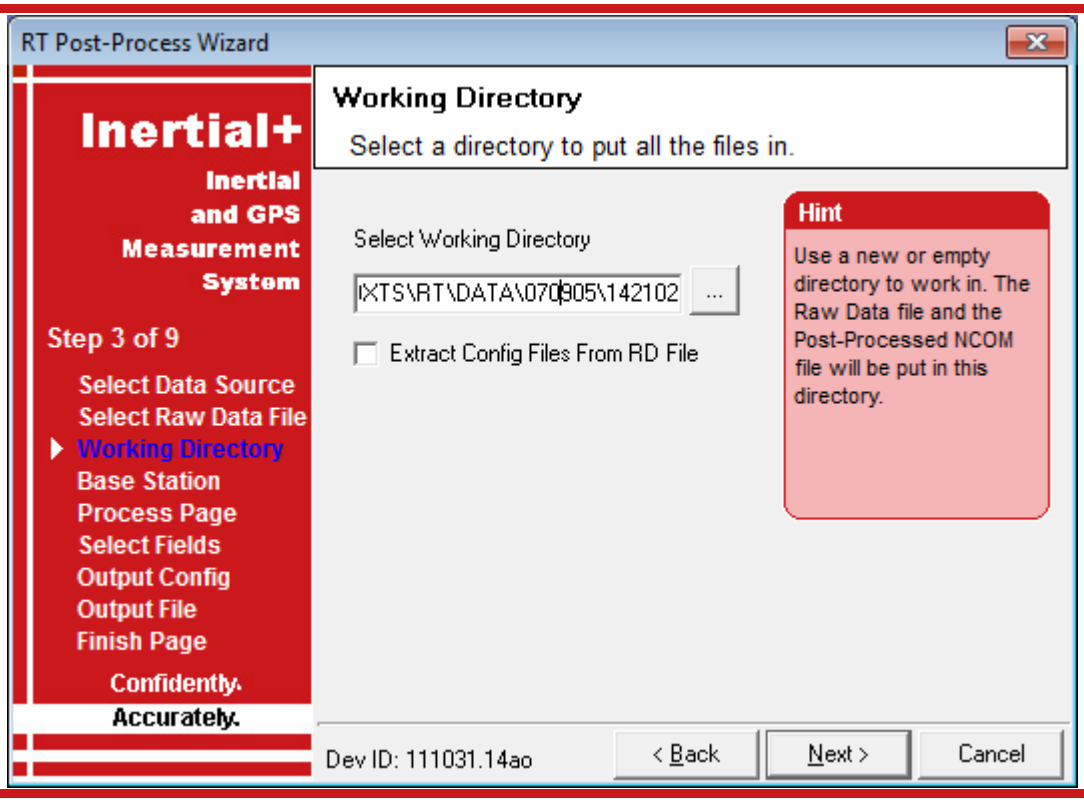
The working directory is where the data will be processed. The output files will be written to this directory. The configuration files should be placed in this directory before processing.

It is important to only have one RD file in each directory while processing. The configuration files all start with the filename "mobile". This means that only one configuration can exist in each directory. When RT Post-process is running, it will create a sub-directory for its work and the sub-directory has a fixed name with fixed filenames within that sub-directory. For these reasons you can only process one RD file in each directory. Putting two RD files in the same directory and then processing them at the same time will lead to confusion.

If the RD file is already in a different directory then the software will copy the RD file to the working directory before processing. This can be useful when trying to process the file multiple times with different configurations.

Figure 5 shows the "Select Working Directory" page.

Figure 5. Select Working Directory page



Either enter the directory name in the edit box or use the "…" button to select the working directory. If the directory does not exist then it will be created.

It is possible for the software to extract the configuration files from the RD file. To do this, check the "Extract Config Files From RD File" checkbox. If this is unchecked and the RD file has been copied from the RT then the current configuration files that are on the RT will be copied to the working directory. Note that the current configuration files on the RT may have been changed since the RD file was created and they may not have the correct configuration in them. It is important to make sure that the correct configuration files are used.

One of the main reasons why people have problems with RT Post-process is because they do not have the correct configuration files with the RD file when they start processing. Take care to make sure you have the correct configuration files before starting to process the RD file.

Base Station

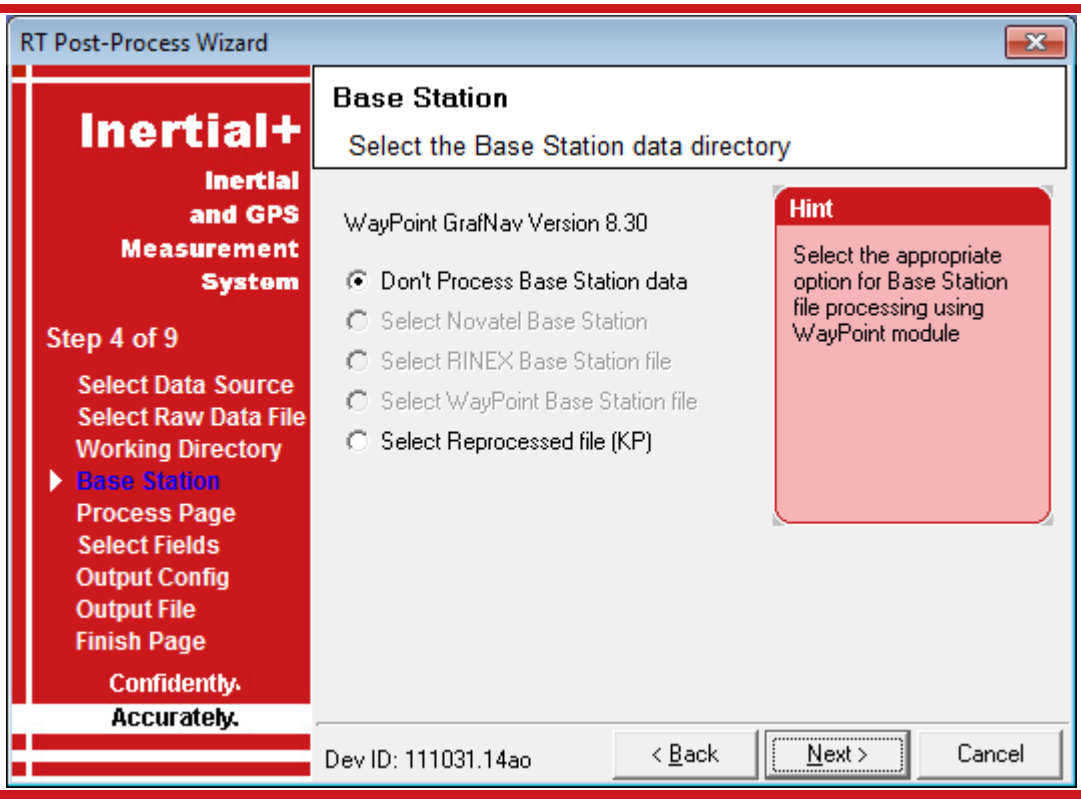
RT Post-process is able to use GPS measurements that have been post-processed. When using an Inertial+ the software from the GPS receiver manufacturer should be used to post-process the GPS.

Normally RT Post-process will use GrafNav to post-process the GPS measurements. If GrafNav is not installed then the software will jump over this page and go straight to the Process page. It is necessary to go back to this page by going to the Process page then clicking on the "Base Station" text in the steps on the left hand side of the page.

RT Post-process only covers the basic features of processing in GrafNav. It is designed to be quick and simple. When more advanced features are needed then it will be necessary to extract the raw GPS data and process in GrafNav's graphical interface.

Figure 6 shows the Base Station page. In Figure 6 post-processing is not possible because RT Post-process does not support post-processing using the GPS receiver that was attached to the Inertial+. See "Reprocessing GPS data outside of RT Post-process" for a solution to this.

Figure 6. Base Station page



If GrafNav is not found then use the "…" button to search for the directory where GrafNav is located. Once a supported version of GrafNav is found then the radio buttons will be enabled.

RT Post-process currently does not support GrafNav version 8.2. Novatel have declined to release the API for this version.

Don't Process Base Station data. This option can be used to ignore base-station data. Use the Next button to move to the Process page. Note that if there is a "KP" file in the directory then it will not get deleted and so the base-station data in the KP file will get used even if this option is selected.

Select Novatel Base Station. This option can be used if a base-station file in Novatel's format is available. The OxTS GPS-Base normally saves its measurements in Novatel's format. When this option is selected the software will show an option to select the base-station location and to select the base-station file. See below for a description of the base-station location.

Select RINEX Base Station. This option can be used if a RINEX base-station is available. RINEX is the most common type of base-station. When this option is selected the software will show an option to select the base-station location and to select the base-station file. See below for a description of the base-station location.

Select Waypoint Base Station file. This option can be used if a base-station file in Waypoint's GrafNav format (GRB) is available. Note that it is important to have the right sample rate in the GRB file. This must be at the same data rate as the GPS receiver. For most RT products this is 2Hz. For the RT2500 and RT2502 the data rate should be 4Hz. For Inertial+ the data rate must be the same as the data rate of the raw data being logged by the Inertial+. When this option is selected the software will show an option to select the base-station location and to select the base-station file. See below for a description of the base-station location.

Select Reprocessed file (KP). This option can be used with other GPS processing software. It will be available even if GrafNav is not installed. When this option is selected an option to extract and save the raw GPS information to a file will be available. The format that the file is written in depends on the receiver used in the RT or external receiver in the Inertial+. More information is provided for this below.

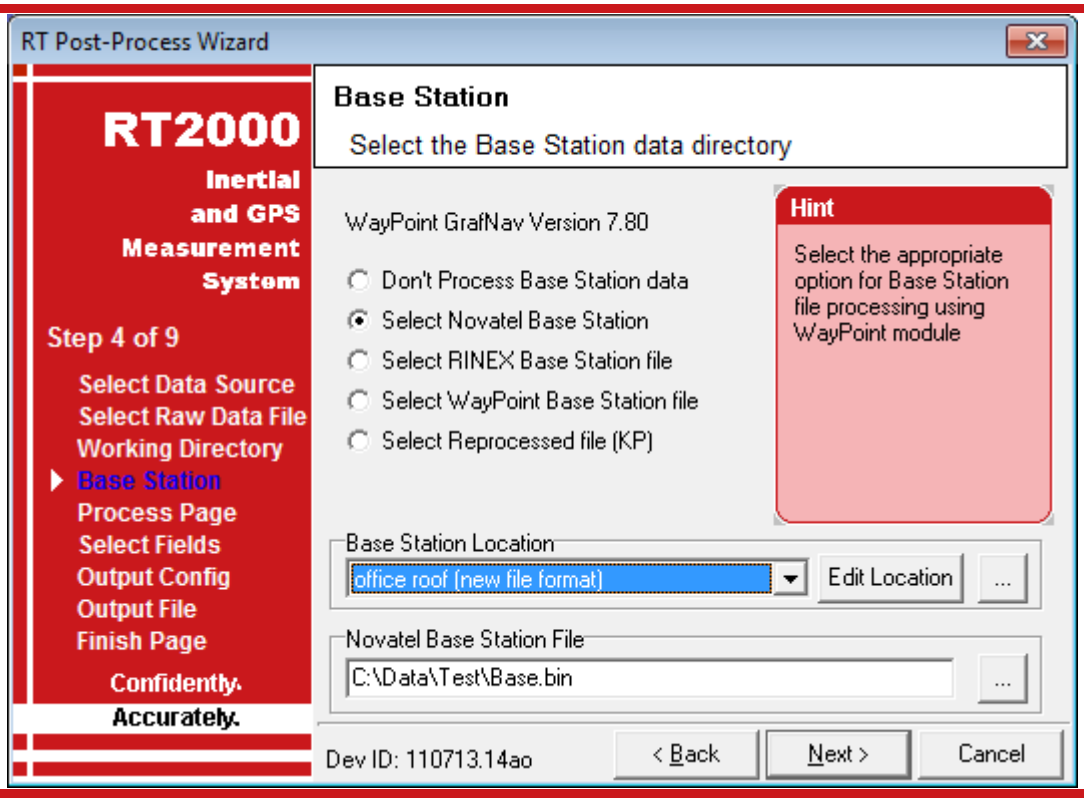
Configuring the Base Station Location

It is important to know the position of the base-station precisely. If an approximate location is used then any error in the base-station location will be included in the position of the RT. This can be useful if you want to offset the RT's position to a slightly different location. If you are trying to plot the RT on a map then it is important to know the base-station location on the map.

RT Post-process is expecting the co-ordinates of the base-station to be in the WGS-84 reference frame. It is best to measure the location of the base-station in this reference frame and then transform the outputs of the RT to the desired co-ordinate frame afterwards.

Figure 7 shows the "Base Station Location" group box. Rather than entering the base-station location each time, the base-station locations are saved and read from a directory so that they can be reused.

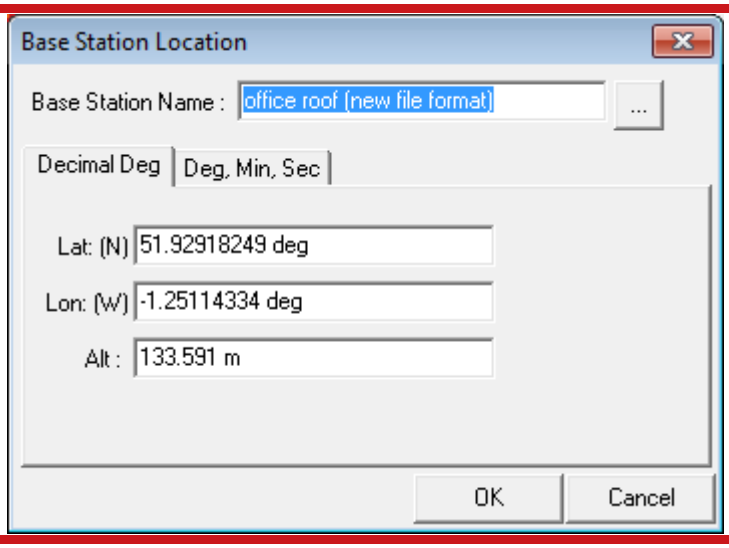
Figure 7. Base Station Location group box



To select a base-station location for this data set use the dropdown list. This lists all the base-station files in the directory. To change the directory press the "…" button and select a new directory; the dropdown list will be updated.

To select a new location or to edit a current location use the "Edit Location" button. This opens the "Base Station Location" dialog box as shown in Figure 8.

Figure 8. Base Station Location dialog



The base-station location entered must be the location of the antenna's phase centre. RT Post-process does not use an antenna model and an antenna reference point. The co-ordinates of the antenna's phase centre can be entered in decimal degrees or in degrees, minutes and seconds. Use the tabs to swap from one format to the other.

The base-station name can be changed at the top of the dialog box. If the same name is used then the old location will be overwritten.

Reprocessing GPS data outside of RT Post-process

Although GrafNav can be used with RT Post-process there are times when it is better to process the data in GrafNav itself, rather than use the standard configuration that RT Post-process uses. For example, if multiple base-stations are available or if a special processing option is needed.

With the Inertial+ different post-processing software will be needed. For example Topcon provides Topcon Tools for reprocessing the data from Topcon receivers. It is possible to save the Topcon data in the Inertial+, export it from RT Post-process then import the processed data after it has been processed using Topcon Tools. This applies to other GPS receivers too.

It is possible to keep the external GPS receiver completely separate from the Inertial+ and then only combine the external receiver with the Inertial+ after it has been post-processed. For example, log the raw data required for post-processing in the external GPS receiver, post-process it, format it in the KP file format and then import it into RT Post-process. Because the Inertial+ has its own GPS receiver(s) all the measurements

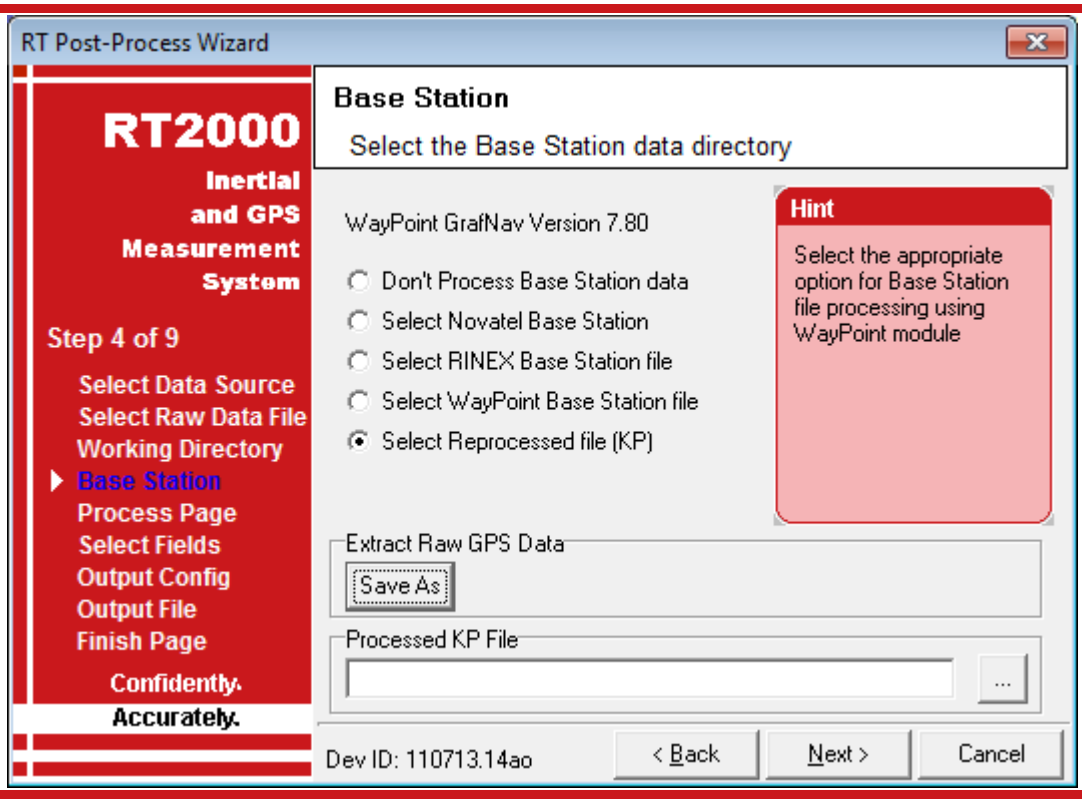
are already time-stamped to GPS time all the measurements can be combined together correctly.

GrafNav can be used to post-process receivers other than those made by Novatel but it will be necessary to export the receiver's data and use GrafNav's user interface rather than relying on RT Post-process to do this.

Other software that can be used includes TRACK from MIT's GAMIT-GLOBK suite. This software is very good with long base-lines. OxTS has a tool that can convert the output of TRACK so that it can be used with RT Post-process.

Figure 9 shows the "Extract Raw GPS Data" group box and the "Processed KP file" group box.

Figure 9. Extract Raw GPS Data group box



To save the raw GPS data, click on the "Save As" button in the "Extract Raw GPS Data" group box. After the raw data has been processed and formatted in the KP format, enter the filename in the "Processed KP file" edit box or use the "…" button to select the file.

Saving KP files from GrafNav

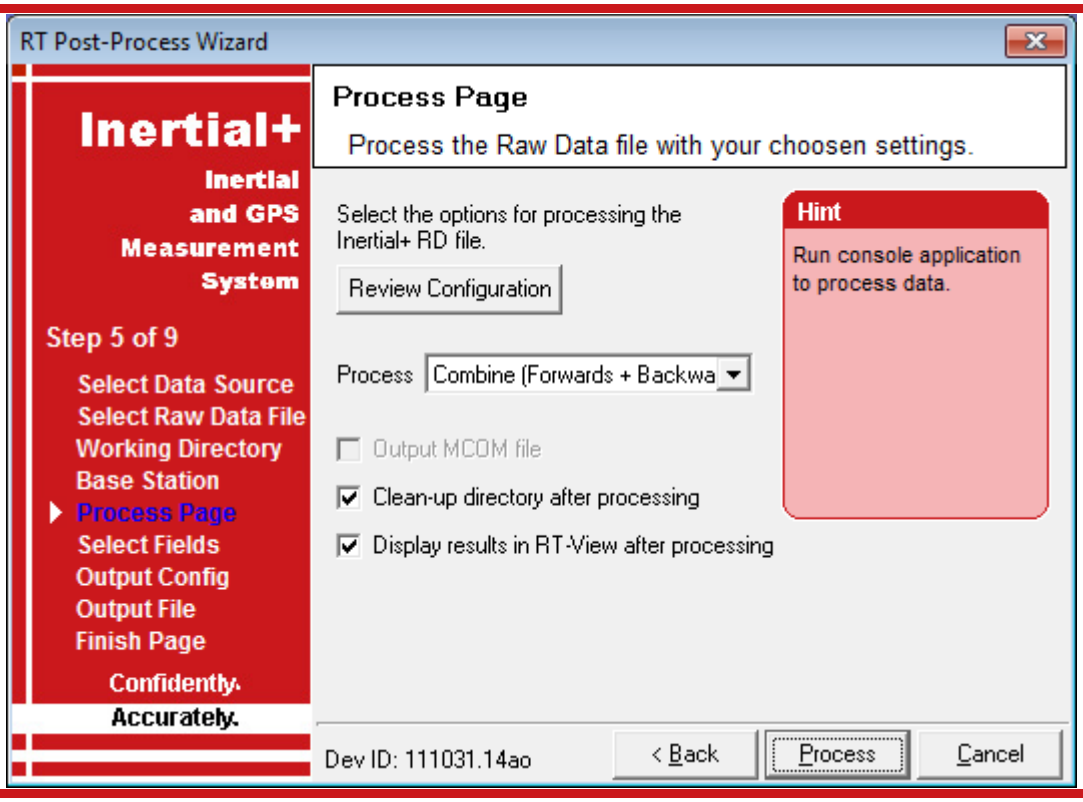
Data is exported from GrafNav using the Export Wizard in the Output menu. To export in the KP format it is necessary to have the GrafNav configuration file for the KP format; this file is called "OxTS KP format.prf". It is installed in the "Program Files\OxTS" folder and it needs to be copied to the "Novatel\WayptGPS*xxx*" folder so that GrafNav can find it.

After the file is copied then the "OxTS KP format" will be listed in the Export wizard in GrafNav.

Process Page

The Process page has the option to review the configuration settings before the processing begins. Figure 10 shows the Process page.

Figure 10. Process Page



To review and change the configuration or settings click on the "Review Settings…" button. This will run RT-Config (or i+config) where the settings can be changed. Some of the settings do not apply to post-processing and these are not automatically identified

by RT-Config. For example, it is not possible to change the differential corrections used during post-processing.

Two processing techniques are offered by RT Post-process. These are listed in Table 1.

Table 1. Processing techniques in RT Post-process

Technique	Description
Simulated (real-time)	This technique processes the data forward in time using an algorithm that is virtually identical to the real-time processing. The only difference is that the Kalman filter in the real-time processing takes time to process, so its corrections are applied between 30 and 100ms later. This occasionally leads to differences in the data.
Combine (Forwards + Backwards)	This technique uses the best processing techniques available, including processing the data forwards and backwards in time and combining the results together. For backwards processing to work the file must be able to "initialise" backwards.

Processing using the "Combine (Forwards and Backwards)" technique gives better results but it is essential that the data can be initialised backwards.

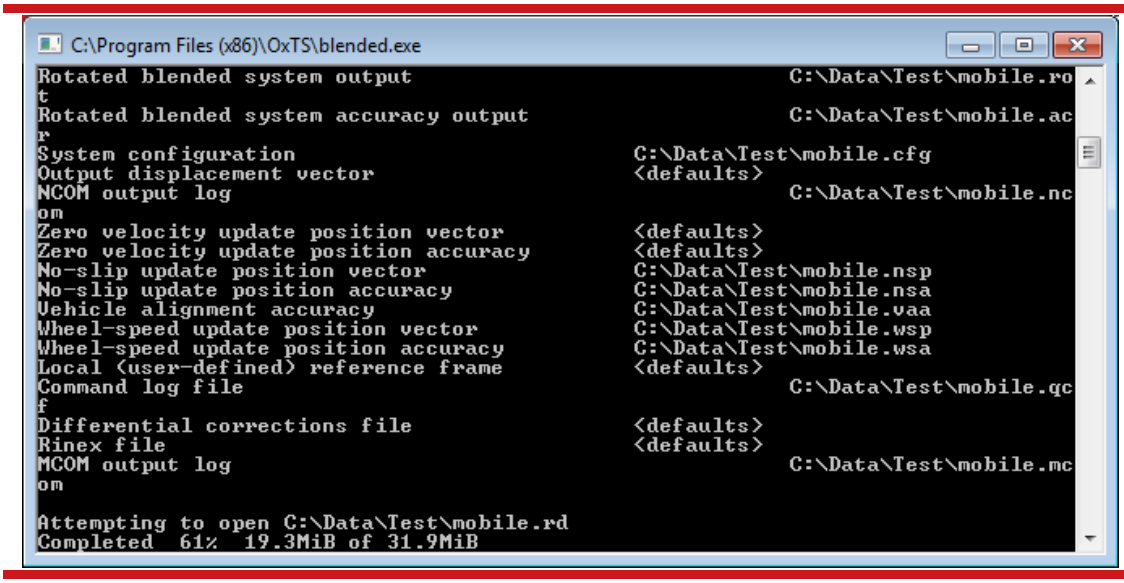
Output MCOM file. An MCOM file can be output while processing. This option is only available using the "Simulated (real-time)" technique. This file format is supported for marine applications and is not used by most OxTS applications.

Clean-up directory after processing. RT Post-process will generate a lot of files during processing, which take up space on the disk. These are placed in different sub-directories. To clean up these files after processing select this option. The software will leave the kp file from any GPS processing in place so that the GPS does not need to be reprocessed.

Display results in RT-View after processing. After processing the results can be displayed in RT-View automatically. Checking this option will automatically launch RT-View after the processing completes.

To start processing the data click the "Process" button. This will launch a console application (blended.exe) that is used to blend the inertial and GPS data together and give the optimal output. This application is shown in Figure 11. When processing forwards and backwards in time, two console applications will be displayed.

Figure 11. Process console application (blended.exe)

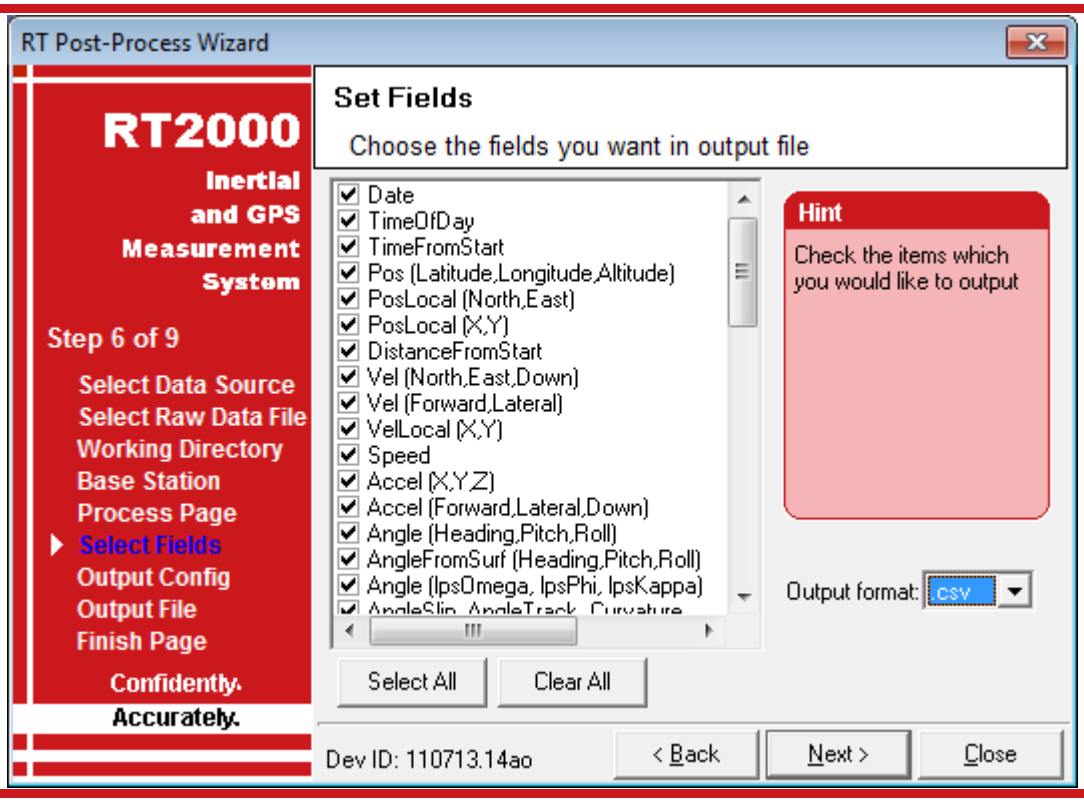

C:\Program Files (x86)\OxTS\blended.exe
Rotated blended system output C:\Data\Test\mobile.rot
Rotated blended system accuracy output C:\Data\Test\mobile.acr
System configuration C:\Data\Test\mobile.cfg
Output displacement vector <defaults>
NCOM output log C:\Data\Test\mobile.ncom
Zero velocity update position vector <defaults>
Zero velocity update position accuracy <defaults>
No-slip update position vector C:\Data\Test\mobile.nsp
No-slip update position accuracy C:\Data\Test\mobile.nsa
Vehicle alignment accuracy C:\Data\Test\mobile.vaa
Wheel-speed update position vector C:\Data\Test\mobile.wsp
Wheel-speed update position accuracy C:\Data\Test\mobile.wsa
Local (user-defined) reference frame <defaults>
Command log file C:\Data\Test\mobile.qcf
Differential corrections file <defaults>
Rinex file <defaults>
MCOM output log C:\Data\Test\mobile.mcom
Attempting to open C:\Data\Test\mobile.rd
Completed 61% 19.3MiB of 31.9MiB

The processing creates an NCOM file that can be loaded into RT-View and is used for the export pages further on in the RT Post-process wizard. After the processing finishes, the Select Fields page will be shown.

Select Fields page

The Select Fields page can be used to select which fields are used to export the data. Currently three different file types can be exported in text format. These are “CSV”, “POS” and “OTA” (Optech ASCII). The Select Fields page is shown in Figure 12.

Figure 12. Select Fields page



To select the output format for the file use the "Output format" dropdown list on the right hand side of the page, under the hint box.

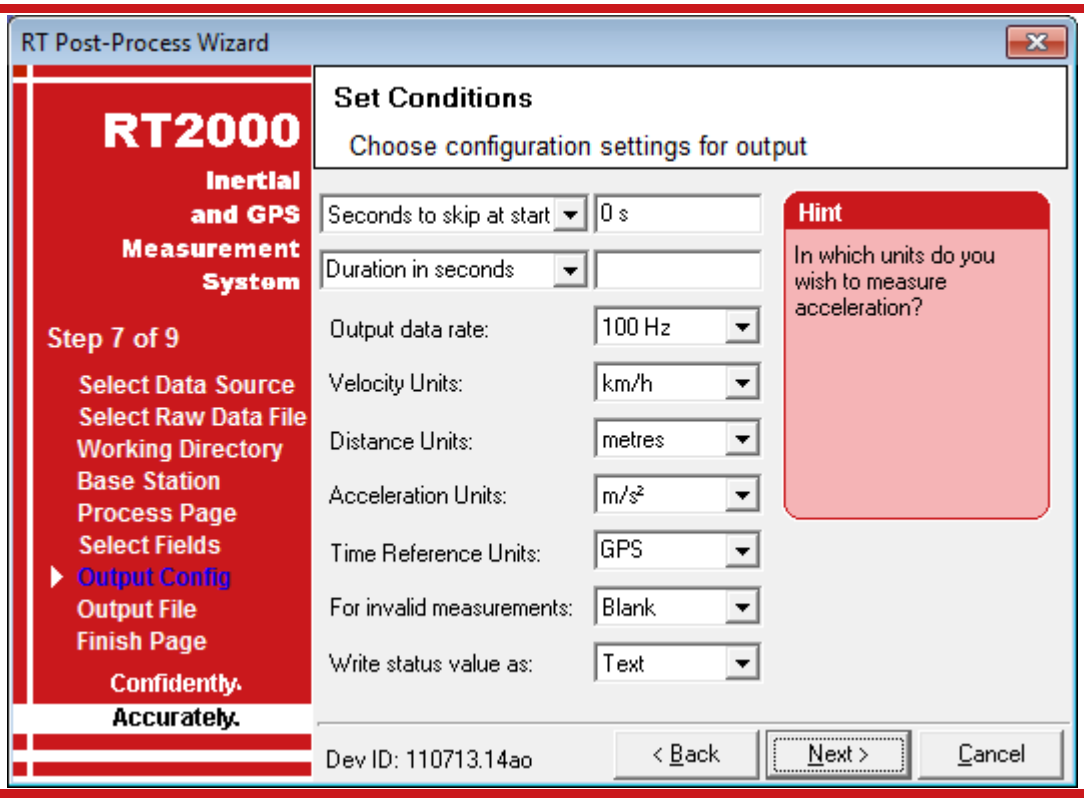
For the CSV export there are lots of fields and they can be enabled or disabled as required.

For the POS and OTA files the fields can be selected but the format is only correct when all the fields are used.

Output Configuration page

The Output Configuration page can be used to select some of the units used and to set some conditions for the outputs (for example, if data should be skipped at the start of the file, etc.). The Output Configuration page is shown in Figure 13.

Figure 13. Output Configuration page



The RD file may contain a lot of data and only a short section may be required. The top two lines can be used to crop the file. The first line selects where the output file will start. Three options exist, as listed in Table 2.

Table 2. Output Conditions Start Time

Condition	Description
Seconds to skip at start	This is the number of seconds that should be skipped after the start of the NCOM file. This will include any time when the RT was not initialised.
Start Time (hh:mm:ss)	This is the start time (of the day) in the Time Reference Units listed below.
Seconds after initialising	This is the number of seconds that should be skipped after initialisation of the RT.

The second line selects the duration for the file or a time when the file should stop being output. Table 3 shows the stop conditions that can be used.

Table 3. Output Conditions End Time

Condition	Description
Duration in seconds	This sets the duration of the output file in seconds.
Stop Time (hh:mm:ss)	This sets the stop time (of the day) in the Time Reference Units listed below.

The other options are listed below.

Output data rate. The data rate can be cut down (decimated) from the original data rate in the NCOM file. No filtering is used to do this; instead epochs are simply not written to the output file. The dropdown list should automatically identify 250Hz if a 250Hz NCOM file is used.

Velocity Units. This option can be used to change the velocity units.

Distance Units. This option can be used to set the distance units. RT Post-process will inherit the distance "hold" or "free" mode from the communication page of Enginuity. In hold mode the distance will not increment when the velocity output becomes sufficiently small so that the RT has a high probability of being stationary.

Acceleration Units. This option can be used to set the acceleration units. Note that the value for G is fixed. G is not a useful value for acceleration measurement because the acceleration due to gravity changes depending on where you are on the earth's surface. Although the RT uses a gravity model in its calculations this is not used in RT Post-process.

Time Reference Units. This option can be used to set the units for time in the output files. The NCOM file always writes files using the GPS time system. RT Post-process can convert this to UTC (or GMT) time by adding the UTC offset to time. RT Post-process can also convert the time to the local time used on the PC by using the time zone selected in the PC.

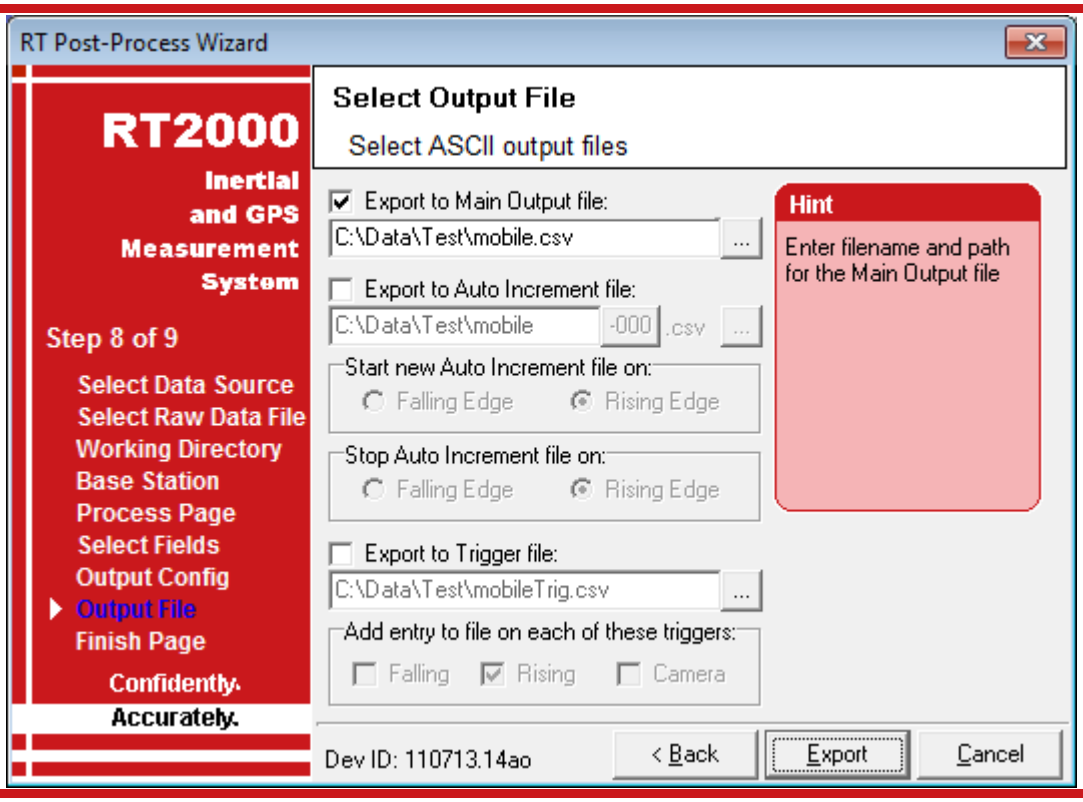
For invalid measurements. This option can be used to decide what to write when there are invalid measurements. NCOM includes a method of defining some measurements as "not valid" and this can be written into CSV files by using a blank field. However, some software does not accept blank fields; RT Post-process can fill in blank fields with zeros or it can hold the last known value.

Write status values as. This option can be used to decide whether status values (e.g. GPS Position Update) should be written as text or as a number. For graphing the values a number is needed.

Output File page

Three different files can be output by RT Post-process. The "Main Output" file starts and ends at the times defined on the Output Configuration page. The "Auto Increment" file starts and stops based on the event input of the RT. The "Trigger" file has one line for each event input on the RT. The Output File page is shown in Figure 14.

Figure 14. Output File page

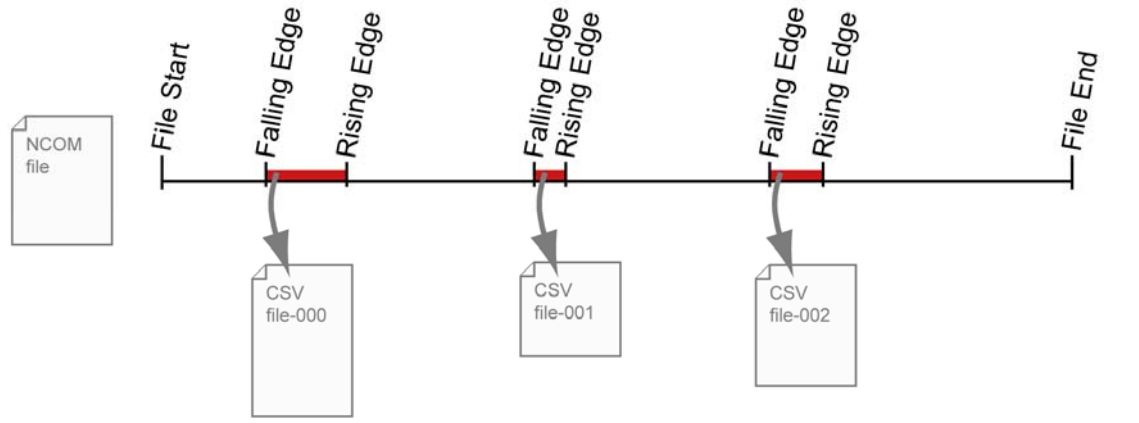


Each option is listed below. More than one option can be used at the same time.

Export to Main Output file. This option should be used to output one file from the start time to the end time as defined by on the Output Configuration page. Use the "…" button to select the filename. Note that RT Post-process will not overwrite an existing CSV file and the field will be blank if the default file exists. This file will need to be deleted before RT Post-process can output.

Export to Auto Increment file. This option can be used to divide the NCOM file into multiple output files using the event input to the RT. Options to start and stop each file are in the group boxes below the checkbox. The file can be started and stopped on the rising edge or the falling edge of the event input. An example showing the event input and the output files is shown in Figure 15.

Figure 15. Auto Increment file output



In this example RT Post-process would be set to start a new Auto Increment file on the falling edge and to stop the Auto Increment file on the rising edge. When the first falling edge in the file is found then the first file will be created; when the rising edge is found then the first file is closed. The length of the file depends on the duration between the two event inputs. This example is typical of a switch being placed between the event input and ground; when the switch is closed the output file starts and when the switch is opened then the output file stops. An internal pull-up resistor in the RT pulls the event input high (causing a rising edge) when the switch is open.

If the falling edge (or rising edge) is used for both starting and stopping the Auto Increment file, then the first event will start the file and the second event will stop the file.

RT Post-process will interpolate the first and last packets in the Auto Increment file to the exact times of the event input. The other measurements are aligned to the GPS clock

The "-000" button shown next to the filename edit box for the Auto Increment file can be used to set the value appended to the filename for the first file that is output. The "…" button can be used to select the filename.

Export to Trigger file. This option can be used to write a file with one line (records) for every event input. For example the event input may be connected to the shutter of a camera and each time the camera shutter closes an event occurs (probably a falling edge, followed by a rising edge) and a line can be written to the Trigger file.

The Trigger file can be written using the falling edge, the rising edge or using the camera output on the Inertial+, or a combination of all three.

Finish page

The Finish page gives the option to open the directory where the output file was written after the wizard closes. Check the “Launch Explorer on Completion” to open the folder when Finish is pressed.

Requirements for Combined (forwards + backwards) processing

When processing backwards there are some tips needed in order to get the best results. Many files will process backwards correctly, but some will not. Here is a list of things that can improve the processing or stop it from working.

- A file that ends in a garage can cause problems when processing backwards. Sometimes the GPS works poorly in the garage, causing the system to initialise when it shouldn't.

- The end of the file should have a clean brake, from a suitable velocity to a standstill, in a straight line. It should be in a good GPS environment. This is the same as initialising at the beginning of the file, but now the vehicle should be braking instead of accelerating. The vehicle should be going forwards during the brake. Do not reverse above the initialisation speed into a parking space at the end of a file.

- A "warm-up" period at the end of the file will help the Kalman filter achieve the best results. Like the warm-up at the start of the file, the best warm-up is a series of figure-8's in open sky conditions, at different speeds, with some straight line, constant speed motion in the middle of the figure-8.

- The end of the file should have good GPS conditions, even if a warm-up is not possible. Rather than ending the test in the middle of city conditions, drive out to more open sky conditions for a few minutes before turning off the RT.

- Systems requiring static initialisation should remain stationary in open sky at the end for long enough so that the static initialisation will work. Static initialisation rarely takes longer than 1 minute in open-sky conditions, especially with the pitch constraint. However, it may be best to remain stationary for at least 5 minutes, or longer, if static initialisation is going to be used.

- On trains it is common to have a configuration that will not initialise until the user tells the RT which direction it is going. This will work when processing backwards but it is essential to have a command at the end of the file to tell the RT which direction it was going.

- Some commands sent to the RT while running will cause problems. For example, if the local co-ordinates, roll, pitch or slip angles are changed while processing (using the Quick Config in Enginuity) then combined processing will not work correctly. It is essential to have a "configuration" RD file, set the configuration, then use a separate RD file for the tests.

File formats

This is an advanced section of the manual and is not needed for many applications. Most of the files described here are output files from either blended.exe (left in the working directory) or the text files from RT Post-process. The input files include the RD file, the configuration files and the KP file. The only input file described here is the KP file.

POS file

The POS file is output by RT Post-process and is used with several laser scanning systems. It includes the time, position and orientation so that laser scans can be corrected. Although some fields can be dropped, for the file to be correct all the fields should be output by RT Post-process; use the "Select All" button to select all the fields before writing the file. The file is written in text format with space separation between the fields and a <CR> at the end of each line.

Table 4. POS file format field description

Column	Field	Description
1	Time of day	This is the time of day in seconds starting at midnight.
2	Latitude	This is the latitude in decimal degrees.
3	Longitude	This is the longitude in decimal degrees.
4	Altitude	This is the altitude in metres. It will be the ellipsoidal or geoidal altitude depending on the configuration in RT-Config (or i+config).
5	Roll	This is the roll angle in degrees.
6	Pitch	This is the pitch angle in degrees.
7	Heading	This is the heading in degrees.

An example line from the POS file is:

37299.750 51.40270413 -0.47022959 10.740 -2.400 4.290 130.060

OTA file

The OTA file is output in the Optech ASCII format. This is a text format that can be used with Optech's software so that the laser points can be geo-referenced. It includes the time, position and orientation. Although some fields can be dropped, for the file to be correct all the fields should be output by RT Post-process; use the "Select All"

button to select all the fields before writing the file. The file is written in text format with comma separation between the fields. No header is included.

Table 5. OTA file format field description

Column	Field	Description
1	UTC Time of day	This is the time of day in seconds starting at midnight and always in UTC time (to match the output of the NMEA ZDA message).
2	Latitude	This is the latitude in radians.
3	Longitude	This is the longitude in radians.
4	Altitude	This is the ellipsoidal altitude, regardless of the configuration in RT-Config or i+config. It is output in metres.
5	Roll	This is the roll angle in radians.
6	Pitch	This is the pitch angle in radians.
7	Heading	This is the heading in radians.

An example line from the OTA file is:

382899.750,0.8971464315,-0.0082070546,-36.335,-0.0419,0.0749,2.2700

(Note that the altitude in this example is below the ellipsoid.)

Output files from blended.exe

There are several output files created by blended.exe. The NCOM file (which has its own manual) is the main output file. There are some output files in text format that can also be used. Many of the files are used by the engineers at OxTS for developing the algorithms and their format is not described here. Future versions of RT Post-process may clean-up some of the files after processing.

Table 6. Output files from post-processing

File extension	Description
.ncom	This is the main output file that contains all the measurements. This is the only file that is combined from forwards and backwards processing.
.mcom	This is an extended version of ncom that has space for some additional measurements.
.prn, .rot	These files are the navigation measurements output in text format. Their format is described below.
.acy, .acr	These files contain accuracy information and some of the states from the Kalman filter. Their format is described below.
.qcf	This file lists all the commands that were sent to the command interface of the RT while it was running.

The software also makes some files called "result.*" and these are used by the developers. They contain information about the inertial sensors early on during the processing that can be used to improve the performance during the warm-up period.

PRN and ROT file format

The PRN file and the ROT files are output by blended.exe and have the same format as each other. They both contain the outputs of the inertial measurement system. The difference between the files is that the PRN file outputs the inertial measurements in the IMU co-ordinate frame and the ROT file outputs the inertial measurements in the vehicle co-ordinate frame. For most applications the ROT file is more useful.

The files are written in text format, space separated, with one line for each time epoch. Each line is terminated with a <CR><LF> pair. The fields are listed in Table 7.

Table 7. PRN and ROT file format field description

Column	Field	Description
1	GPS Week	The GPS Week, starting with 6th January 1980 as week 0. The value in this field is always larger than 1023 so it includes the first GPS roll-over. (The satellites only transmit 10 bits for the week.)
2	GPS Time of week	This is the number of seconds into the week. The transition for GPS Time starts between Saturday night and Sunday morning.
3	Latitude	The latitude in decimal degrees. This is normally in the WGS84 co-ordinate system.
4	Longitude	The longitude in decimal degrees. This is normally in the WGS84 co-ordinate system.
5	Altitude	The altitude in metres. This will be the geoidal altitude by default but it can be the ellipsoidal altitude if the default configuration in RT-Config has been changed.
6	Velocity North	The velocity in the north direction in m/s.
7	Velocity East	The velocity in the east direction in m/s.
8	Velocity Down	The velocity in the down direction in m/s. (This is the opposite direction to altitude. It is positive if the altitude is decreasing.)
9	Acceleration X[1]	The acceleration in the X[1] direction in m/s^2.
10	Acceleration Y[1]	The acceleration in the Y[1] direction in m/s^2.
11	Acceleration Z[1]	The acceleration in the Z[1] direction in m/s^2.
12	Heading[1]	This is the heading angle in degrees that defines the relationship between the NED (North, East Down) co-ordinates and the XYZ[1] axes.
13	Pitch[1]	This is the pitch angle in degrees that defines the relationship between the NED (North, East, Down) co-ordinates and the XYZ[1] axes.
14	Roll[1]	This is the roll angle in degrees that defines the relationship between the NED (North, East, Down) co-ordinates and the XYZ[1] axes.
15	Angular Rate X[1]	The angular rate along the X[1] direction in degrees/s.
16	Angular Rate Y[1]	The angular rate along the Y[1] direction in degrees/s.
17	Angular Rate Z[1]	The angular rate along the Z[1] direction in degrees/s.

Note 1. In the PRN file the axis will refer to the axis of the IMU and in the ROT file the axis will refer to the axis of the vehicle. The orientation page of RT-Config (or i+config) will define the relationship between the IMU and the vehicle axes.

An example line from the PRN or ROT file is:

1649 303259.8000 51.92932584 -1.25077123 123.581 8.954 1.727 -0.210 2.130 -0.591 -10.505 10.83 -0.06 0.10 2.73 -1.12 -0.95

ACY and ACR file format

The ACY and ACR files are output by blended.exe and have the same format as each other. They both contain accuracy and state information that can be used as an indicator on how accurate the RT believes it is. The difference between the files is that the ACY file is in the IMU co-ordinate frame and the ACR file is in the vehicle co-ordinate frame. These files are always output with a data rate of 1Hz.

The files are written in text format, space separated, with one line per second. Each line is terminated with a <CR><LF> pair. The fields are listed in Table 8.

Table 8. ACY and ACR file format field description (columns 1 to 14)

Column	Field	Description
1	GPS Week	The GPS Week, starting with 6th January 1980 as week 0. The value in this field is always larger than 1023 so it includes the first GPS roll-over. (The satellites only transmit 10 bits for the week.)
2	GPS Time of week	This is the number of seconds into the week. The transition for GPS Time starts between Saturday night and Sunday morning.
3	Latitude stdev	The estimated standard deviation of latitude in degrees.
4	Longitude stdev	The estimated standard deviation of longitude in degrees.
5	Altitude stdev	The estimated standard deviation of altitude in metres.
6	Velocity North stdev	The estimated standard deviation of velocity in the north direction in m/s.
7	Velocity East stdev	The estimated standard deviation of velocity in the east direction in m/s.
8	Velocity Down stdev	The estimated standard deviation of velocity in the down direction in m/s.
9	Accelerometer X bias	The bias (or offset) applied to the accelerometer in the IMU X axis in m/s^2.
10	Accelerometer X bias stdev	The estimated standard deviation of the bias of the accelerometer in the IMU X axis in m/s^2.
11	Accelerometer Y bias	The bias (or offset) applied to the accelerometer in the IMU Y axis in m/s^2.
12	Accelerometer Y bias stdev	The estimated standard deviation of the bias of the accelerometer in the IMU Y axis in m/s^2.
13	Accelerometer Z bias	The bias (or offset) applied to the accelerometer in the IMU Z axis in m/s^2.
14	Accelerometer Z bias stdev	The estimated standard deviation of the bias of the accelerometer in the IMU Z axis in m/s^2.

Table 9. ACY and ACR file format field description (columns 15 to 29)

Column	Field	Description
15	Heading[1] stdev	The estimated accuracy of heading in degrees.
16	Pitch[1] stdev	The estimated accuracy of pitch in degrees.
17	Roll[1] stdev	The estimated accuracy of roll in degrees.
18	Gyro X bias	The bias (or offset) applied to the gyro in the IMU X axis in degrees/s.
19	Gyro X bias stdev	The estimated standard deviation of the bias of the gyro in the IMU X axis in degrees/s.
20	Gyro Y bias	The bias (or offset) applied to the gyro in the IMU Y axis in degrees/s.
21	Gyro Y bias stdev	The estimated standard deviation of the bias of the gyro in the IMU Y axis in degrees/s.
22	Gyro Z bias	The bias (or offset) applied to the gyro in the IMU Z axis in degrees/s.
23	Gyro Z bias stdev	The estimated standard deviation of the bias of the gyro in the IMU Z axis in degrees/s.
24	Gyro X scale factor	The scale factor (or gain) applied to the gyro in the IMU X axis.
25	Gyro X scale factor stdev	The estimated standard deviation of the scale factor of the gyro in the IMU X axis.
26	Gyro Y scale factor	The scale factor (or gain) applied to the gyro in the IMU Y axis.
27	Gyro Y scale factor stdev	The estimated standard deviation of the bias of the gyro in the IMU Y axis.
28	Gyro Z scale factor	The bias (or offset) applied to the gyro in the IMU Z axis.
29	Gyro Z scale factor stdev	The estimated standard deviation of the bias of the gyro in the IMU Z axis.

Note 1. In the ACY file the axis will refer to the axis of the IMU and in the ACR file the axis will refer to the axis of the vehicle. The orientation page of RT-Config (or i+config) will define the relationship between the IMU and the vehicle axes.

Table 10. ACY and ACR file format field description (columns 30 to 39)

Column	Field	Description
30	GPS antenna lever arm X	The lever arm from the IMU measurement point to the GPS antenna phase centre in the IMU X axis in metres.
31	GPS antenna lever arm X stdev	The estimated accuracy of the lever arm from the IMU measurement point to the GPS antenna phase centre in the IMU X axis in metres.
32	GPS antenna lever arm Y	The lever arm from the IMU measurement point to the GPS antenna phase centre in the Y axis in metres.
33	GPS antenna lever arm Y stdev	The estimated accuracy of the lever arm from the IMU measurement point to the GPS antenna phase centre in the IMU Y axis in metres.
34	GPS antenna lever arm Z	The lever arm from the IMU measurement point to the GPS antenna phase centre in the IMU Z axis in metres.
35	GPS antenna lever arm Z stdev	The estimated accuracy of the lever arm from the IMU measurement point to the GPS antenna phase centre in the IMU Z axis in metres.
36	Dual-antenna heading	The heading angle rotation between the IMU and the dual-antenna GPS in degrees.
37	Dual-antenna heading stdev	The estimated heading angle rotation accuracy between the IMU and the dual-antenna GPS in degrees.
38	Dual-antenna pitch	The pitch angle rotation between the IMU and the dual-antenna GPS in degrees.
39	Dual-antenna pitch stdev	The estimated pitch angle rotation accuracy between the IMU and the dual-antenna GPS in degrees.

Other fields at the end of the ARY and ACR files should be ignored.

An example line from the ACY or ACR file is:

1648 487956.000 0.00004630 0.00006105 10.001 0.176 0.171 0.105 -0.00002 0.00500 0.00000 0.00500 0.00000 0.00500 1.639 1.643 5.785 -0.0016 0.5003 0.0042 0.4999 -0.0028 0.4999 -0.0000 0.0100 0.0000 0.0100 0.0000 0.0100 -0.700 0.100 0.000 0.100 0.000 0.100 -34.630 5.000 90.000 4.991 0.000 5.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

KP Input File

The KP input file is used to read post-processed GPS data into blended.exe so that it can be combined with the inertial data. GPS is often post-processed so that it can be corrected by a base-station. If there is a measurement in the KP file then it will be used instead of the real-time measurement from the GPS. When there is no measurement in the KP file then the real-time measurement from the GPS will be used instead.

The KP file is in text format, with space separated values and a <CR><LF> at the end of each line. Each line represents one time epoch. Table 11 lists the fields in the KP file. All of the fields in the file are mandatory.

Table 11. KP file format

Column	Field	Description
1	GPS Week	The GPS Week, starting with 6th January 1980 as week 0. The value in this field is always larger than 1023 so it includes the first GPS roll-over. (The satellites only transmit 10 bits for the week.)
2	GPS Time of week	This is the number of seconds into the week. The transition for GPS Time starts between Saturday night and Sunday morning.
3	Quality number	This field is not used by blended.exe.
4	Number of satellites	This is the number of satellites used in the solution.
5	Latitude degrees	The degrees component of latitude.
6	Latitude minutes	The minutes component of latitude.
7	Latitude seconds	The seconds component of latitude.
8	Longitude degrees	The degrees component of longitude.
9	Longitude minutes	The minutes component of longitude.
10	Longitude seconds	The seconds component of longitude.
11	Ellipsoidal Altitude	The ellipsoidal altitude in metres.
12	North stdev	The standard deviation of the latitude in metres.
13	East stdev	The standard deviation of the longitude in metres.
14	Altitude stdev	The standard deviation of the altitude in metres.
15	Velocity North	The velocity in the north direction in m/s.
16	Velocity East	The velocity in the east direction in m/s.
17	Velocity Up	The velocity in the up direction in m/s.
18	Velocity North stdev	The standard deviation of the velocity in the north direction in m/s.
19	Velocity East stdev	The standard deviation of the velocity in the east direction in m/s.
20	Velocity Up stdev	The standard deviation of the velocity in the up direction in m/s.

An example line from the KP file is:

1464 225945.500000 1 8 51 56 36.12254 -1 14 53.29741 180.0011 0.012804 0.010920 0.022326 -0.020 -0.002 -0.006 0.156128 0.133996 0.261583

Revision History

Table 12. Revision History

Revision	Comments
110907	Initial version
111102	Added combined (forwards and backwards) processing.